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Schedule-Independent Factors Contributing to Schedule-Induced Phenomena

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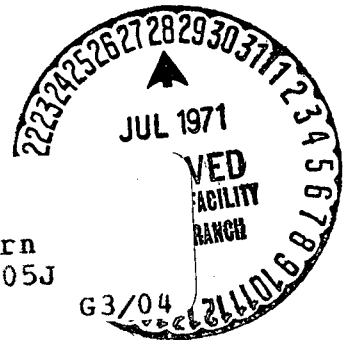## Acknowledgements

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SCHEDULE-INDEPENDENT FACTORS CONTRIBUTING TO SCHEDULE-INDUCED PHENOMENA

I. Introduction

This conference and its topics of discussion represent a general acknowledgement, by us and by a number of other workers, that there are frequent behavioral by-products which result during ongoing programs of contingent response control. An experiment often produces major secondary effects which are not to be understood in terms of the contingent relations between the events manipulated by the experimenter and the primary performance. As more research has produced these frequent behavioral by-products certain of their principal characteristics have been established. Thus, the regularity of "schedule-dependent" or "schedule-induced" phenomena has been more firmly established in the last several years. In addition to our greater understanding of these performances, we have begun to appreciate that knowledge of such collateral behaviors may also be crucial to a full understanding of the primary performances themselves. The explanatory power of this knowledge of secondary behavioral effects has been recurrently demonstrated. For example, several workers had either speculated upon, or actually experimented with, the possibility that transitions to nonreinforcement for previously reinforced operants were "noxious", "aversive", "frustrating", or "negatively reinforcing". Ferster's (1958) work on contingent timeout from reinforcement in both pigeons and monkeys attempted to demonstrate that such transitions were in fact punishing. Several experiments followed these initial demonstrations in attempting to further support the notion that extinction was a negatively reinforcing condition in the traditional sense of such a term. For example Appel (1963), Azrin (1961), and Thompson (1964) (1965) each illustrated that certain features of positive reward schedules might produce "escape" or timeout responses. Such effects were argued to support the notion that the absence of reward was, in some way, more than the absence of reward and in fact was the presence of some noxious or aversive state of affairs. Such results, however, were fraught with the difficulty that they were generally interpretable in terms of an organism's simply behaving so as to maximize reinforcement in the ongoing baseline program. The demonstration, however, by Azrin, Hutchinson, and Hake (1967) that the transition to conditions of nonreward would produce attack behavior in pigeons and the subsequent experiments by Hutchinson, Azrin, and Hunt (1968) showing that certain portions of a fixed-ratio schedule occasioned attack behavior by monkeys against a rubber hose, each provided additional support for the earlier tests. Here extinction at least in its initiation, was more than simple absence of response strengthening, since its onset directly produced an independent novel (and collateral) behavior similar or identical to the behavior pro-

duced by the direct delivery of a painful electric shock. Another
example of knowledge of a collateral behavior providing assistance
in understanding other behaviors would be the findings of Azrin,
Hutchinson, and Hake (1967) that nonperformance of avoidance or es-
cape reactions, if resulting in shock, could lead directly to attack
behavior by rats and monkeys and that, in turn, these reactions often
proved suitable as avoidance or escape responses, and would thus be
learned especially rapidly. Similar findings have been made in the
area of polydipsia, where an understanding of the collateral behavior
and the contingently-controlled baseline behaviors have each been
instructive in knowing more about the other.

Though these findings have been helpful to us and to others
interested in the effects of schedules of response contingent stimulus
control, their principal merit may not depend upon a preoccupation with
schedule processes. The work on aggression has made it apparent from
the outset that such behavior was not to be viewed solely or pri-
marily as a "schedule-induced" or "schedule-dependent" effect.
Ulrich and Azrin (1962) showed that attacks were produced directly
by the application of electric shock. Similarly, Azrin, Hutchinson,
and Hake (1966) demonstrated that attack resulted directly from ter-
mination of response-independent food presentations. Thus, during
the last several years we have been conducting experiments in which
we have studied various effects of the direct response-independent
application of events such as electric shock and food upon different
behaviors. The results of these studies provide basic information
about environmental influences on a number of reaction tendencies,
and may hopefully serve as important observations for comparison
with other experiments where such events are manipulated in a
response-contingent fashion.

Many of us here are products of the operant tradition, and
possess a set of psychological knowledges and skills which have been
shown to be of exceptional technological power. In such a comfortable
condition, we tend, however, to neglect the continuing necessity for
certain critical experimental tests. For example, if a particular
response is strengthened during the contingent delivery of food or
shock termination, we all tend to accept the simple response-strength
increase as a sufficient demonstration of the contingent control
relation. Yet we all know that numerous unlearned effects may also
develop over time and, in a more conservative mood, each of us
would suggest that a more thorough test of whether a particular
condition was or was not "reinforcing" would be to study response
tendencies in the absence of such conditions, then in the presence
of contingent events, and finally again in the absence of the con-
tingent events. This ABA design or, as it is often termed, baseline,
reinforcement, and extinction, is a powerful series of manipulations
which we have all come to respect as a reasonable test of the claims
of contingent control. Frequently, however, we do not demand that
such tests be conducted. If the performance in

question is suitably affected, i.e., moves from a low level to a
higher level in the B condition, then down again when we remove those
variables, we may be convinced that the response-contingent event
is responsible for the behavioral increases noted. But is it? We
all appreciate that the contingent application of a stimulus variable
is actually the simultaneous arrangement of two factors: 1) the
establishment of contact between the organism and the agent such as
food or shock, and 2) the contingency arrangement between some unit
of behavior and that stimulus event. This additional factor of the
contingency is the essence of operant conditioning and serves to
distinguish as "learned" or operantly conditioned response strength
so generated from many other performances. Yet again our methods
are so powerful that we often and in fact typically, are convinced
that response strength results from the contingent application of
an event, even though the contingency per se is very frequently
not manipulated. Comparison between the contingent and the non-
contingent application of "biologically-relevant" or "primary
reinforcer" type events is, it seems to us, a crucial but presently
underdeveloped experimental concern within the experimental analysis
of behavior. The work reported here makes some attempts at such
comparisons. In the experiments reviewed most completely here we
have been studying the effects of the experimental manipulation
of painful electric shocks, delivered independent of a subject's
ongoing performances, upon several distinct response classes.

II. Methods

If the work reported here has been successful to any degree, it is a result of the combined efforts of a number of persons who have worked over the years to produce experimental methods incorporating several highly desirable features. The subject paradigm is that originally developed by Dr. Hake at Anna, Illinois, for his thesis work on punishment with the squirrel monkey. The method provides the partial restraint of the subject by an ingenious chair, waist-lock, and tail-yoke assembly, (Hake and Azrin 1963). This chair permits relative freedom of the torso, upper extremities, and head, while severely restricting the general mobility of the animal, and particularly the tail. The later factor is important as it allows the continuing, precise contact with the subject for the purpose of delivering a regulated painful electric shock. This predictable and specifiable shock delivery system seems to us a very marked improvement over most other shock application systems with other species. In the procedure employed, the distal 4 to 5 inches of the tail is shaved and, each day prior to running, cleaned with alcohol. The tail is then placed under the electrodes to make contact at two points. Electrode cream is rubbed into the tail for one minute and then additional paste is applied over these points of contact. Only by such methods is subsequent stimulation predictable and rigorously controllable. As an additional control, tail resistance is monitored both at the beginning and end of each session, and series resistances are employed to further minimize any variation which might yet occur. Such specifiable contact between the environment and the organism becomes mandatory when one is interested in the frequent contact with a precise stimulus condition. Such requirements are certainly found in studies of punishment, escape, and elicited behaviors; perhaps more often than in the study of avoidance behavior, where environmental factors immediately controlling performance are those other than the infrequent shock. In many behavioral studies, most of us are accustomed to an experimental freedom for choosing, strengthening, and manipulating any of a variety of response topographies. This flexibility, afforded through the process of successive approximation and contingency, is not available when studying the effects of response-independent events. Instead, one must be prepared to arrange the delivery of events independently of any experimentally desired behavioral outcome. Further, the researcher must passively record the behavioral actions which result. For this reason, it is necessary to develop response sensors which make contact with performances in ways which do not detract or punish, or in any other way arbitrarily delimit, behavioral expression. In our studies of biting attack, it has been necessary to choose rubber hose types and dimensions which can withstand frequent tearing and ripping contacts. Similarly, in other studies of manual manipulation, it has been necessary to choose sensors, such as chains to be pulled

or levers to be depressed, which are not so lightly counterweighted as to allow continual depression, but instead produce frequent release and subsequent redepression by the subject. The arrangement of these sensors in space is also highly important. If concurrent performances are occurring, response sensors, by their spatial location and physical construction, must provide for the reliable and sensitive, but selective, contact with behaviors.

III. Behavior Production By Aversive Stimuli

A. Unconditional Effects

Upon initial exposure to painful electric shock, a squirrel monkey restrained in a chair, engages in a number of measurable reactions. Typically the shock produces a high-pitched scream and violent struggling, which appears to be an intense effort to escape from the restraint chair. If a rubber hose is suspended in front of the subject's face, the animal will, after several shocks, grasp the hose with both hands, lean forward, and bite for some number of times. This behavior, referred to as biting attack behavior, has been reported by us previously [Hutchinson, Azrin, and Hake (1966), Hutchinson, Azrin, and Renfrew (1968)], and follows closely the general pattern of reactions initially reported by Ulrich and Azrin (1962). Figure 1 illustrates a cumulative record of such behavior over a 60-minute session for one subject during three successive experimental tests. Initially the animal is exposed to a 100-millisecond shock each two minutes, independent of ongoing behavior. Each shock produces a flurry of biting responses for some seconds which then subsides until the next shock. In the second condition, the voltage generator was disconnected and it is seen that biting attacks are immediately eliminated. In the third experimental condition the subject is exposed again to shocks every two minutes and the biting behavior occurs in the original pattern. This illustration shows that the biting performance is caused explicitly and directly by the painful electric shocks. As with all of our work on elicited behavior, very large individual subject differences exist in the absolute magnitude of behavior produced by the stimulus events studied. All, however, have shown the basic pattern illustrated in Figure 1.

The absolute frequency of biting attacks in response to an individual shock are in part determined by the intensity and duration of each shock (Hutchinson, Azrin, and Renfrew 1968). In Figure 2, a transition from a lower to a higher shock intensity is illustrated. Whereas the subject had been receiving 75-volt shocks each 60 seconds, the 200-volt shocks are then presented at the same frequency. All shocks were delivered independent of any behavior. The transition in response frequency occurs immediately upon introduction of the higher voltage. The direct relation between magnitude of biting behavior and the intensity of shock lead to the assumption of a simple and direct relation between biting attack and stimulus magnitude. After additional studies, however, it became clear that the relation is anything but simple. In most of our earlier work, subjects were exposed to only brief episodes of electric shock. In later work as subjects accrued histories over a wider variety of shock conditions, several major processes not initially observed became evident.

Figure 1. Representative record for one subject showing the relation-
ship between shock exposure and biting attack on a rubber hose.
During shock period, 500-volt tail-shock deliveries are indicated
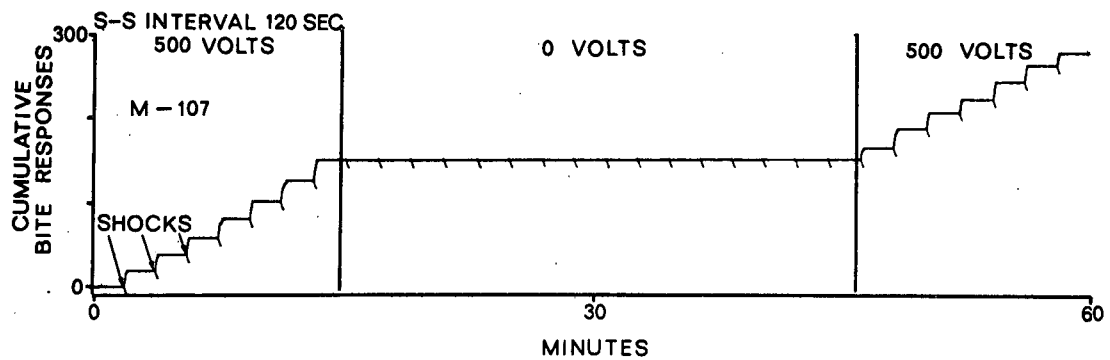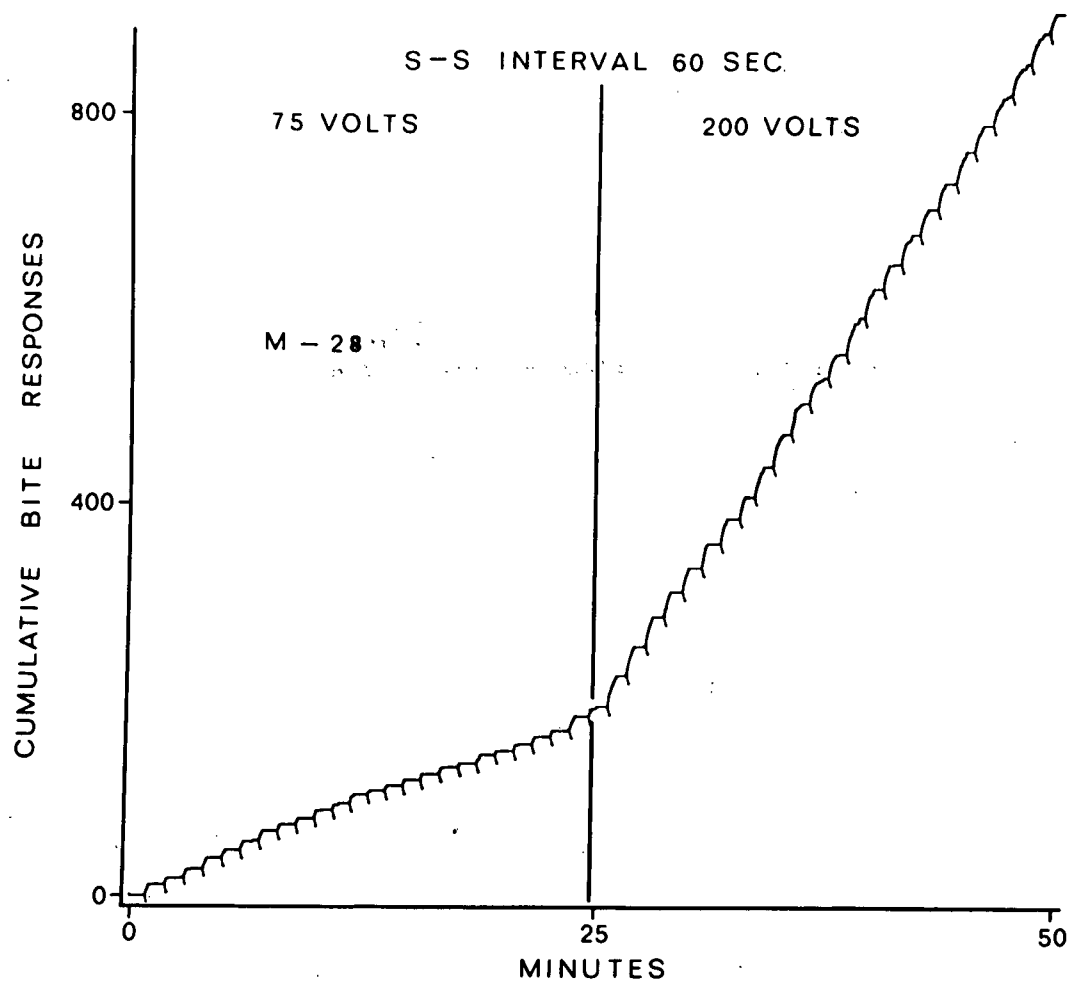by vertical deflections of the cumulative record.

Figure 2. Representative record for one subject showing relative frequency of biting attack at the two shock voltages indicated. Shock deliveries are indicated by vertical deflections of the cumulative record.

First it was discovered that decreased shock intensities did not produce a reduced but unchanging degree of biting attack. In fact, at lower shock intensities attack might occur at modest levels initially, but rapidly decrease over a single session and even more drastically over subsequent sessions. Again there was considerable variability between animals. In Figure 3, the performances for an entire session for three subjects are illustrated. Each of these subjects shows varying degrees of response decrease upon successive shock deliveries. Several studies showed that these response decreases might be fully dissipated over a period of one or two days without testing or shock delivery. Additional experiments showed that the reduction was greater as a function of increased shock frequency. Thus it became evident that biting attack behavior demonstrated response habituation much as do other elicited phenomena. The experiments are reported completely in Hutchinson, Renfrew, and Young (1970).

With some of our subjects however, effects quite the opposite of habituation gradually developed. For these subjects, and under the experimental conditions to which they were exposed, biting attack became progressively more frequent upon successive minutes and sessions of shock exposure. Again, large individual differences in the amount of biting attack to similar or identical shock parameters appeared. In Figure 4, the performances for an entire daily session for four subjects showing this effect are illustrated. These performances are not transitory, but reflect the steady state assumed after some days or weeks of exposure to the experimental conditions. In this case, shocks were delivered each four minutes and shock intensity was 400 volts. Each subject shows a fairly constant number of bites after each shock for the initial 20 to 40 minutes of the experimental session. Gradually, a greater number of bites occurs after each shock until, in some instances, biting occurs continuously at a rate of 2 or 3 per second independent of specific shock deliveries. Again it must be emphasized that these are not performances initially observed, but reflect terminal performance under these conditions. For example, each of the subjects illustrated showed performance identical to that shown in Figure 4 on the following day. Thus the response elevations recurrently appeared upon repeated exposure to conditions similar to those here illustrated. In Figure 5, the development of such performance is shown for one of the four subjects. Subsequent to 10 days of exposure to the conditions noted, performance assumed the same progressively increased pattern as shown in Figure 4. Again let us point out that the performance illustrated on Day 10 is essentially identical to that seen on Day 12, Day 15, and thereafter until conditions of the experiment were altered. Numerous additional experiments clearly showed us that the conditions necessary for these effects, which we have named facilitation, depend upon the delivery
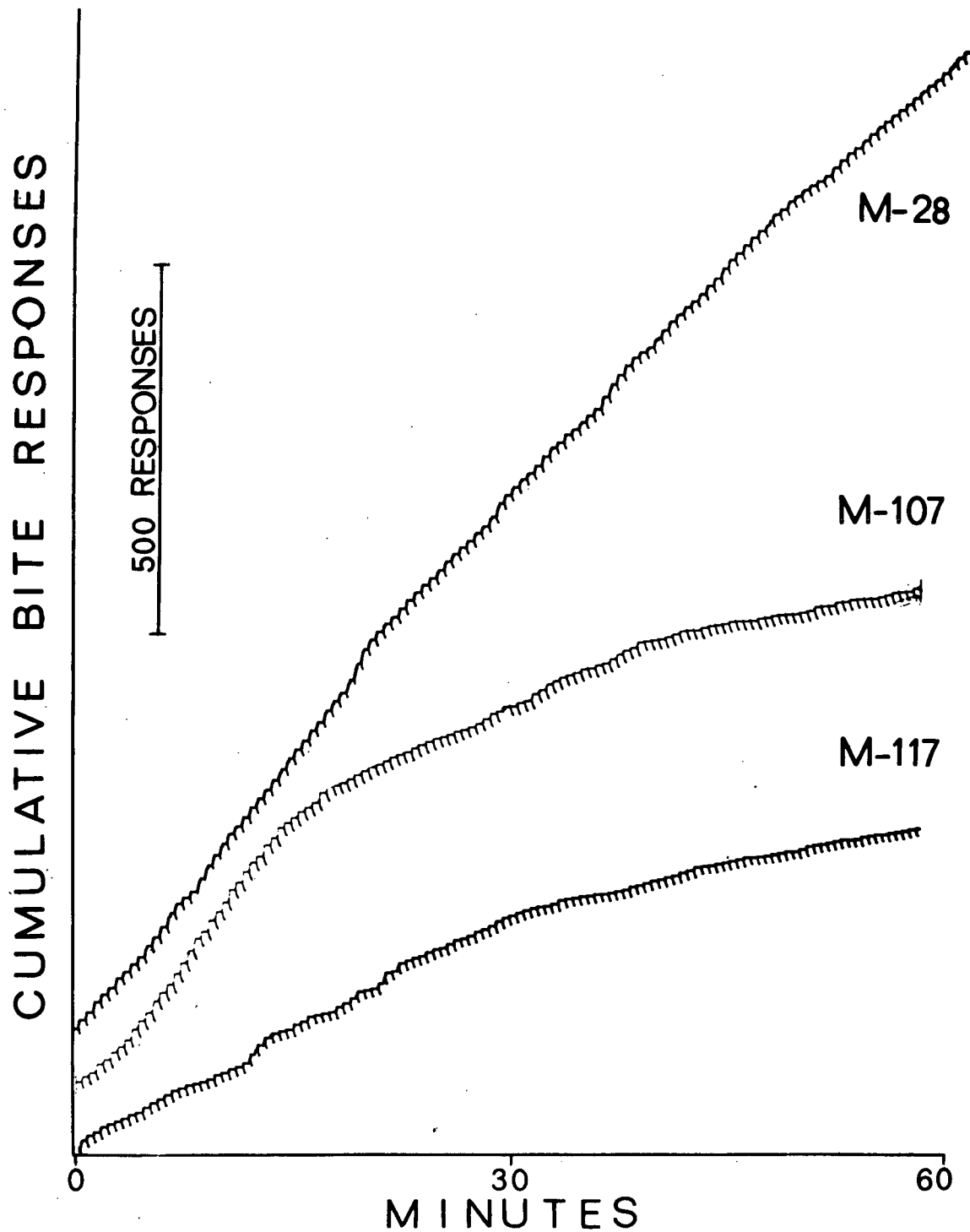
Figure 3. Cumulative records of biting attack of an entire
experimental session for three subjects, showing decrements
in responding within the session. M-28, M-107, and M-117
received 400-volt, 300-volt, and 200-volt shocks, respectively,
where indicated by vertical deflections of the cumulative
record. Shock-shock interval was 30 seconds.

Figure 4. Within-session increases in responding for four subjects exposed to consecutive previous sessions of noncontingent tail shock. 400-volt shock deliveries are indicated by vertical deflections of the cumulative record.
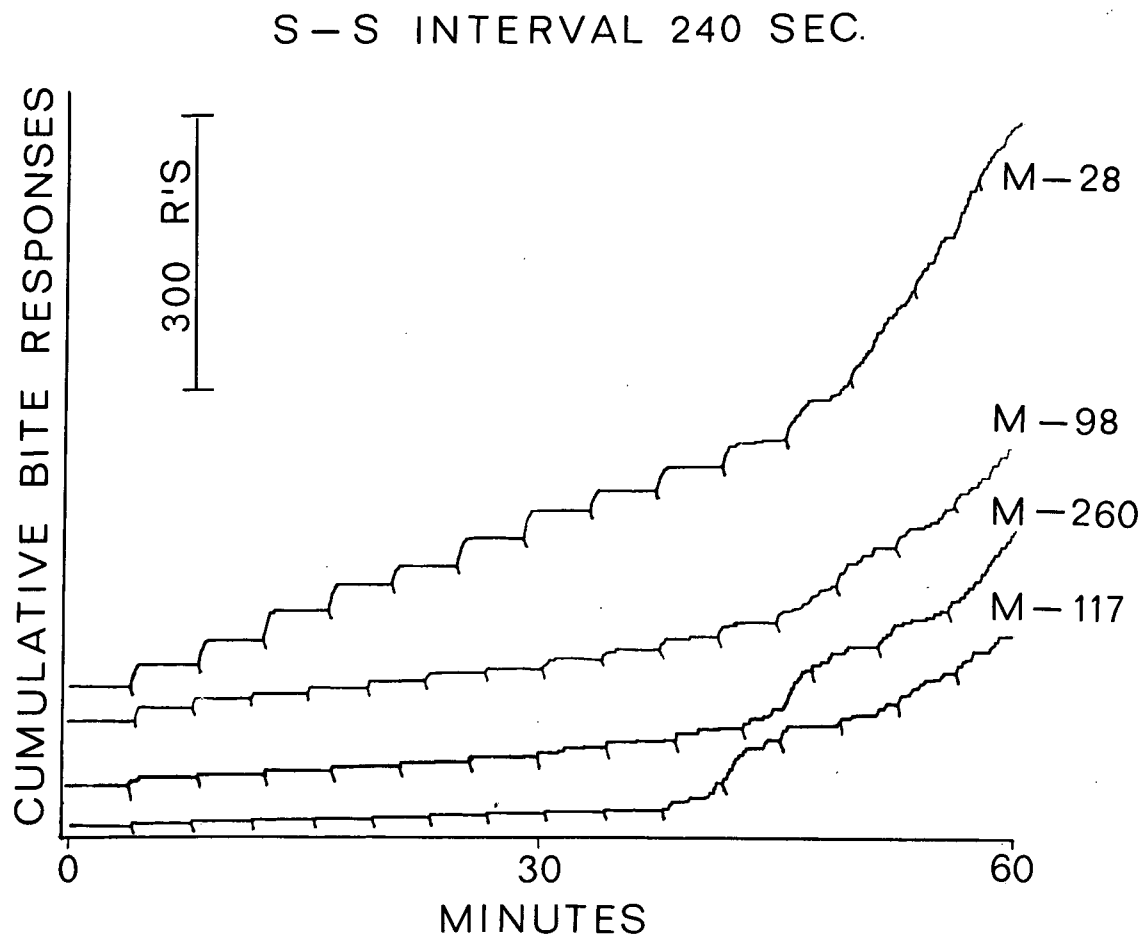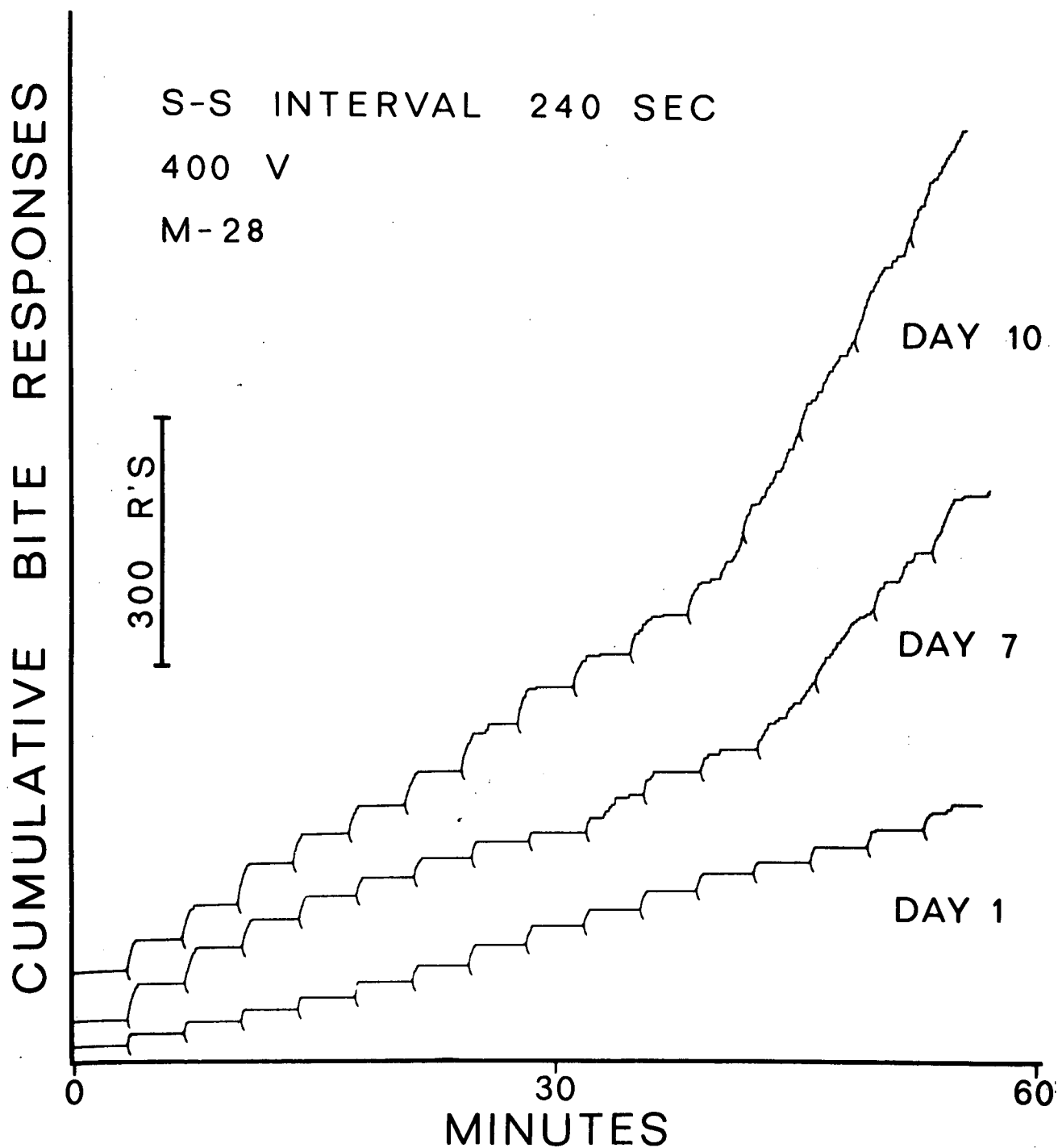

S — S INTERVAL 240 SEC.

Figure 5. Cumulative records of biting attack for one subject showing development of increased responding over successive sessions.

of intense, infrequent electric shock. Stated more precisely, increased shock intensity was shown to produce greater response facilitation effects, and additionally, shock frequency must at least be reduced enough so as not to produce the counter-effect already discussed, that is, response habituation. These experiments are covered more thoroughly in Hutchinson, Renfrew, and Young (1970). It was quite clear at this point that two major long-term changes in biting attacks would result upon continued exposure to shocks of certain intensities and frequencies. The effects noted were often not immediate, but required several days or weeks to develop. Figures 6 and 7 illustrate this gradual development of increased or reduced responding as a function of both shock intensity and shock frequency. It should also be noted that termination of shock did not produce an immediate reduction in biting. Rather, subjects often continued to bite for hours, days, and in some instances for weeks after shock removal.

These effects, of the direct production and habituation or facilitation of biting attacks after prolonged exposure to electric shock, are not unique to this response system alone. About three years ago, we had the good fortune to accidentally observe the occurrence of other behavior, also produced by electric shock. A small response lever had been installed in one of the removable front panels in the restraint chair. The lever was to be used with other subjects in studies of avoidance behavior, but was accidentally in place one day during the experimental session for monkey M-34. This subject was being exposed to electric shocks that were not contingent upon any performance, and biting attacks were being measured. In the left hand portion of Figure 8, the progressive increase in biting attack produced by shocks (response facilitation) is illustrated over a five-day series of shock deliveries. The lower of each pair of tracings in this portion of the figure shows the records obtained of lever pressing concurrent with biting attacks. This lever pressing is replotted cumulatively in the right portion of the figure, which shows that the same facilitation of responding occurs with lever pressing as with biting attacks. During the subsequent three years, this instance of serendipity has lead to a number of studies designed to elaborate more fully the conditions of shock delivery which promote lever pressing. We now know that, in general, the conditions necessary for the continued production and facilitation of this manipulative behavior are the same as those necessary for the production and facilitation of biting attack, i.e. the infrequent delivery of intense electric shocks. Again we have found large individual differences in the magnitude and temporal pattern of behavior generated by these conditions. In Figure 9, the performance of subject MC-23 over a period of 43 days of shock exposure is illustrated. It may be seen that this particular subject developed a

Figure 6. Records for one subject showing increases and decreases in biting attack upon tail shock at the intensities noted. Each point is an average of the total day's bites divided by the number of shocks delivered during that session. No correction for within-session response increments or decrements is provided.
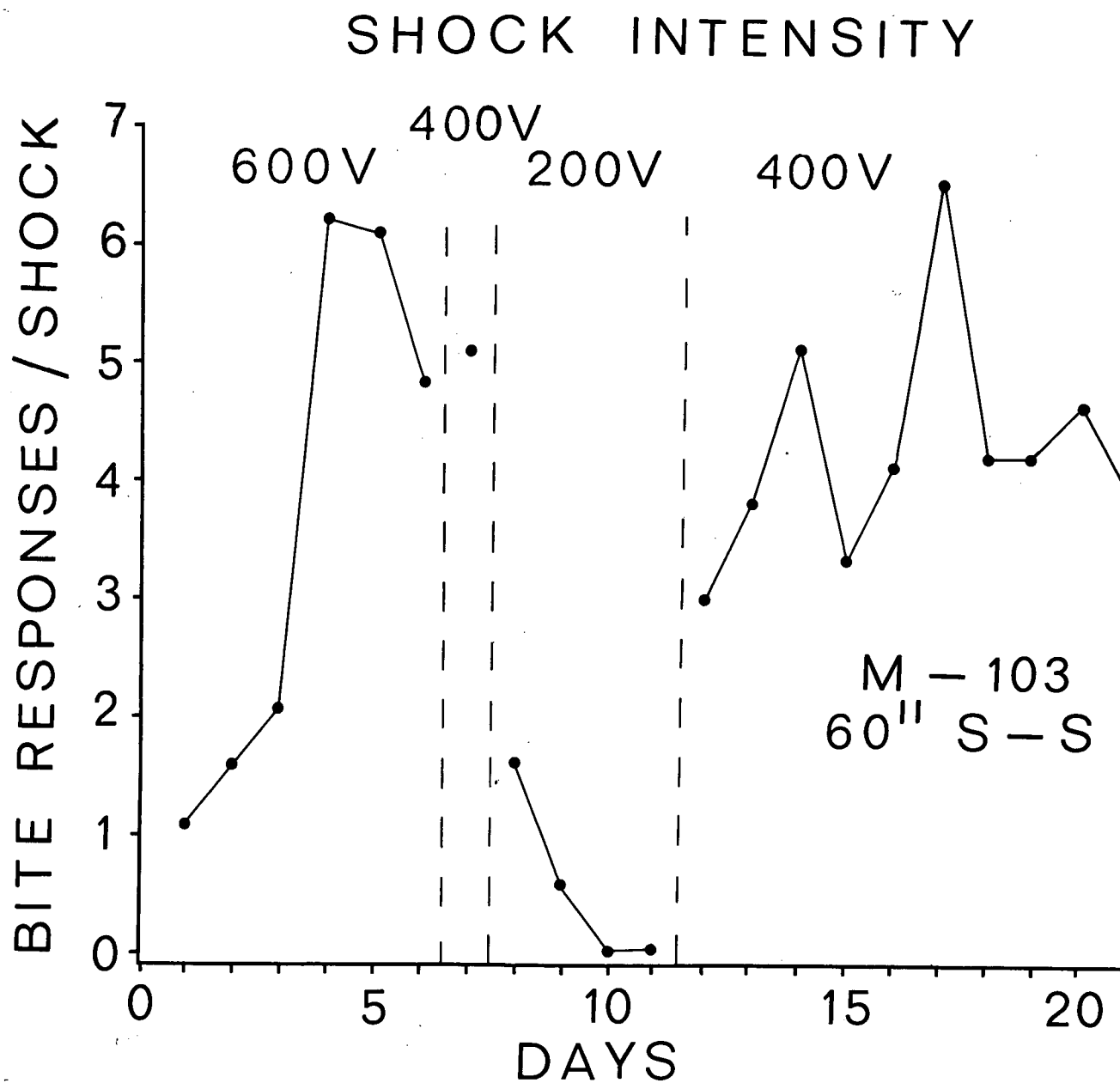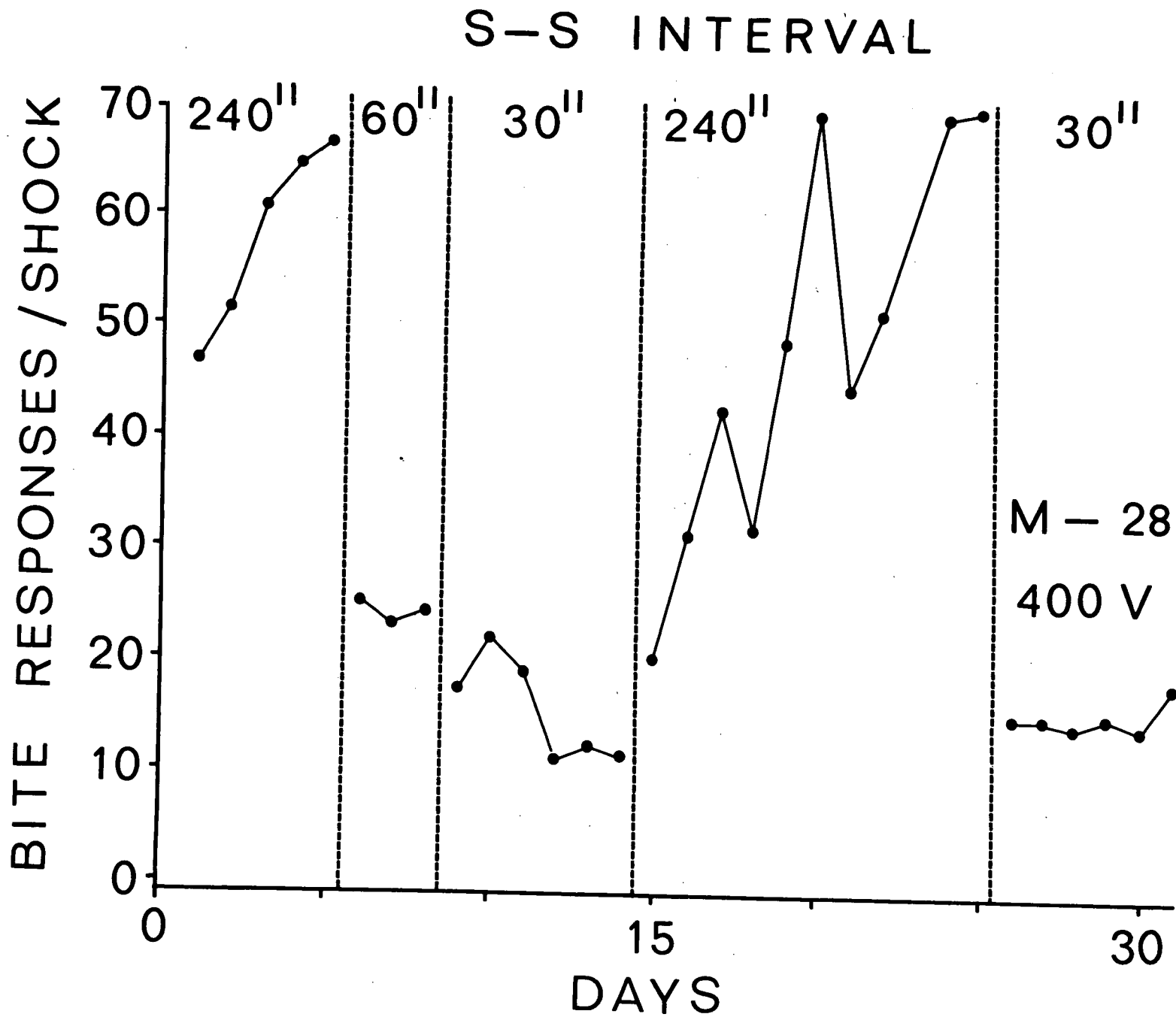
Figure 7. Records for one subject showing increases and decreases in biting attack at the shock-shock intervals noted. Each point is an average of the total day's bites divided by the number of shocks delivered during that session. No correction for within-session response increments or decrements is provided.
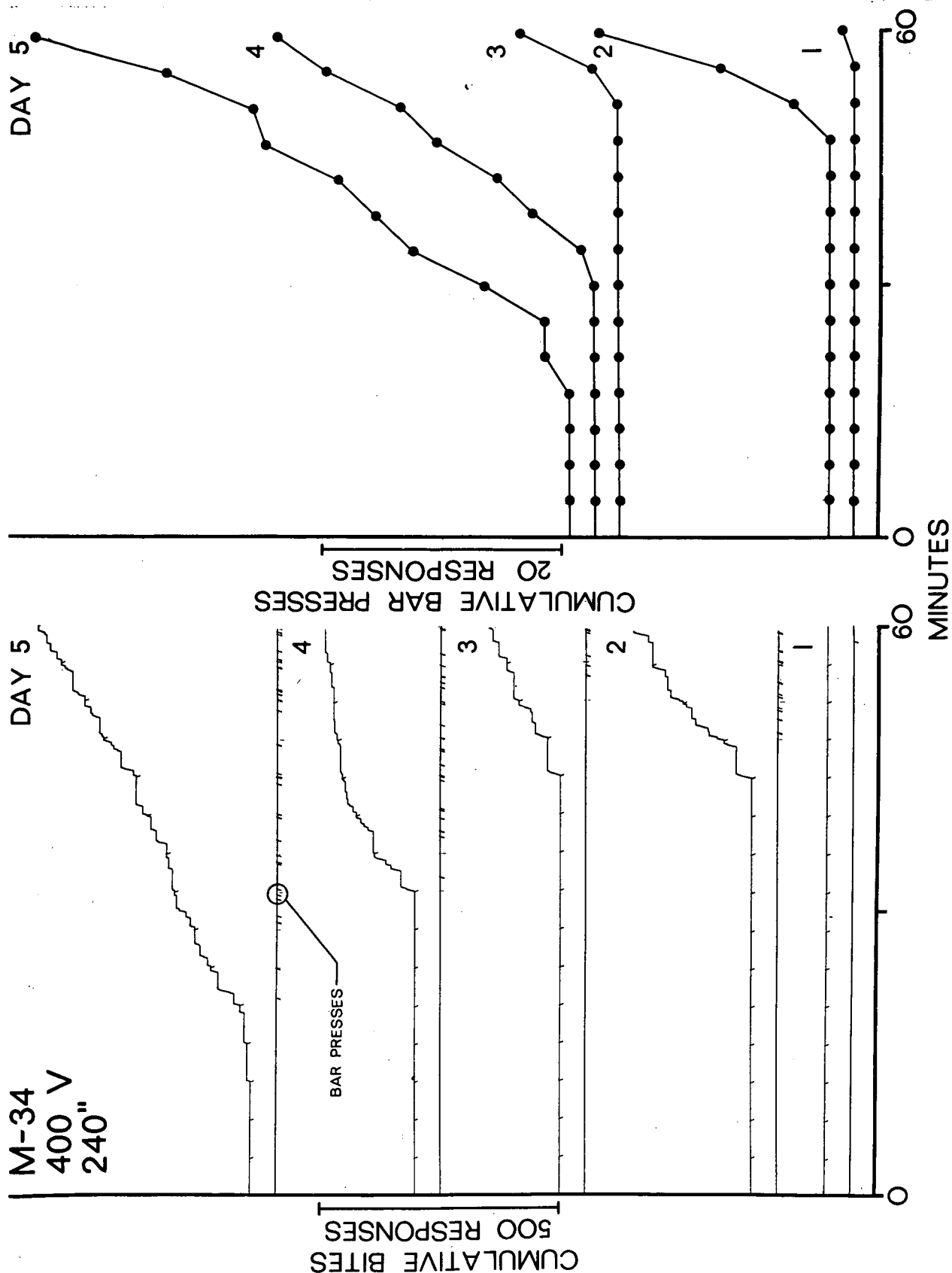
Figure 8. Records for one subject of shock deliveries, hose-biting
responses, and lever (bar) pressing responses. Shock deliveries
are indicated by vertical deflections of the cumulative bite record.
Development of increased responding in both modes is shown over
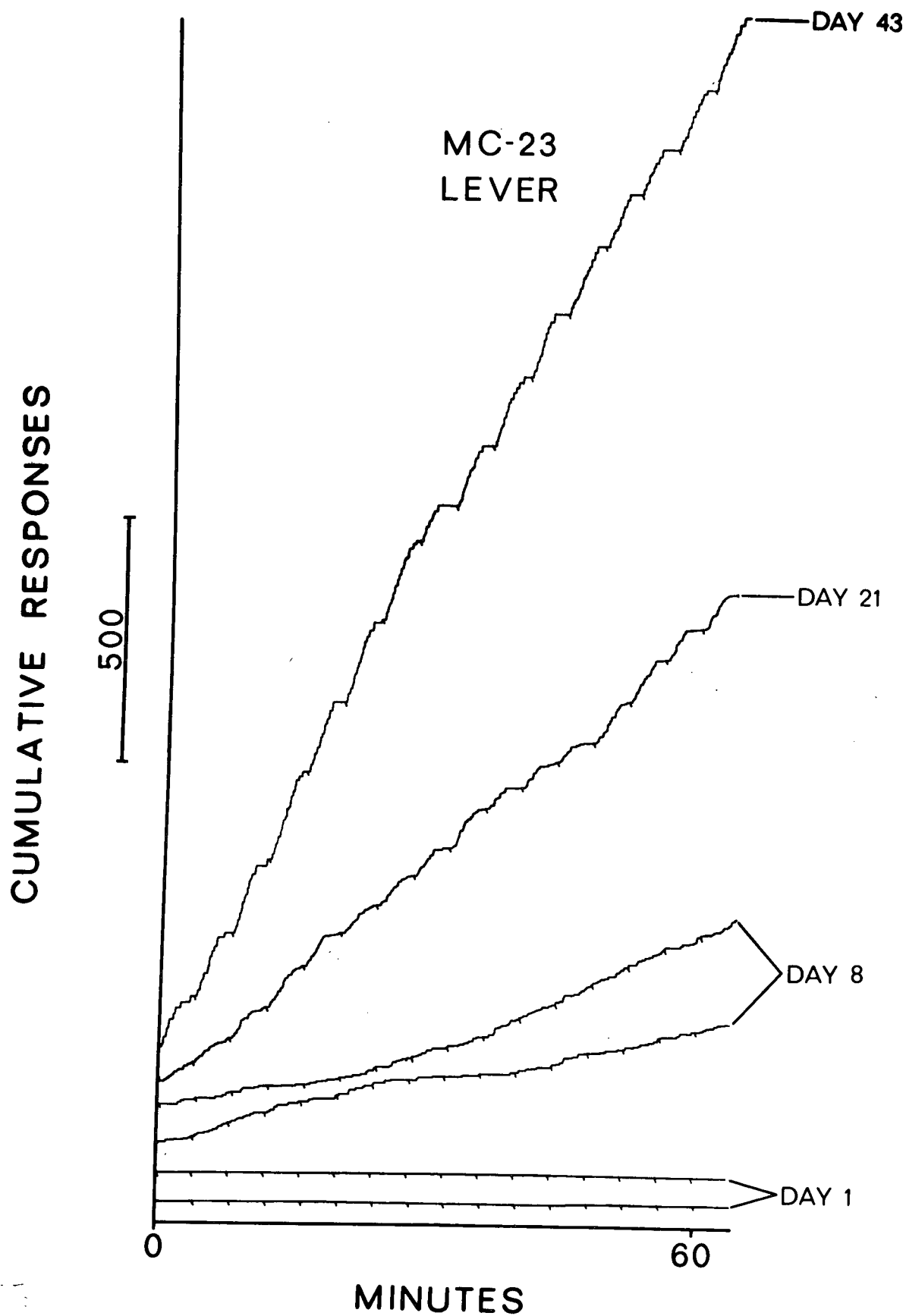five consecutive daily sessions.

Figure 9. Cumulative records for one subject showing development of increased lever-press responding over successive daily sessions of 400-volt, noncontingent tail shock. Shocks, at 240-second intervals, are indicated by vertical deflections of the cumulative record.

progressively higher rate of reaction over successive days of exposure until, by Day 43, the overall response rate often exceeded 50 responses per minute. Upon continued shock application, manual lever pressing gradually assumed a characteristic temporal distribution within the intershock interval. These patterns will be discussed in subsequent sections.

B. Conditional Effects

In our earlier studies of biting attack and again recurrently, in the work with manual manipulative responses, we frequently encountered temporal patterns of behavior which suggested that conditions of the experiment associated with shock delivery, i.e., the passage of time, might in some way be capable of producing reactions independent of shock delivery. Several studies were therefore initiated to determine formally whether the classical conditioning of biting attacks was possible. In Figure 10, the average performance for one subject within the intershock interval for an entire session is illustrated. Ten seconds prior to shock, an interrupted flashing white light was presented. The light and electric shock were coterminous. Subject M-254 came rapidly to bite at the onset of the flashing light and continued, though at a decreased rate, until shock delivery, where the large burst of biting attack responses occurred. Other stimuli not associated with shock did not produce the effects seen in Figure 10. Other studies with lever-press and chain-pull responses indicated that these reactions could also be eventually produced by stimuli associated with shock delivery. Figure 11 portrays the results of an experiment for one subject. In this experiment, subjects were exposed to 80 seconds of continuous, 1500-Hz tone followed immediately by 80 seconds of continuous light. The light and shock were coterminous. Eventually, Subject MC-13 would respond at a gradually higher rate toward the end of the tone stimulus. Responding would decrease briefly in the light stimulus, but rapidly increase toward the moment of shock delivery. Just before shock however, behavior tended to decrease or be suppressed. Subsequent to shock, no responses were evident. The effects upon biting attack and manual manipulation responses by stimuli associated with electric shock have in common the characteristics of response production prior to shock delivery. Attack and manipulative responses, however, appear dissimilar immediately subsequent to shock, where biting attacks tend to occur at a high rate while very little manual manipulative behavior is evident. These differences will be discussed more thoroughly in subsequent sections.

An additional feature which both performances bore to the conditioned stimulus was a progressive increase in responding up to, but slightly before, the moment of shock delivery, but with a response reduction or cessation immediately prior to shock. This effect, of a decrement in responding immediately prior to noncontingent shock delivery, is often characteristic of the process referred to as conditioned suppression. The suppression phenomenon is a general one which we observe in the large majority of cases, in spite of the fact that the decreased performance itself is generated by the same or highly similar stimulus conditions as is the responding which occurred immediately prior to the suppression. Thus the stimuli associated temporally with shock delivery come to

produce both biting attacks and manual manipulative responses,
but stimuli even more intimately associated with shock delivery
can suppress these same performances.

Responding of the type illustrated in Figures 10 and 11 did
not result only during the delivery of explicit external stimuli.
Often, as mentioned earlier, performance came to show a temporal
pattern which strongly suggested the same phenomena experimentally
illustrated in these tests. For example, in Figure 12, the biting
performance of a single subject is shown for an entire experimental
session. Shocks were delivered each 4 minutes. During the inter-
shock interval, a characteristic pattern of performances is evident.
Subsequent to shock, a burst of biting attack responses occur for
some seconds. Following a period without behavior, and gradually
as the time of next shock approaches, attacks increase in frequency
until shortly before shock, when behavior is absent. A sample
segment of this performance is magnified in the lower right-hand
section of the figure. In Figure 13, the temporal pattern fre-
quently seen of lever-press responding is illustrated for one
subject for an entire experimental session. At this point it is
crucial to remember that all shocks were always delivered without
regard to performance of the subject. That is, they are not con-
tingent upon behavior. The figure illustrates quite clearly the
progressive increase in response frequencies up to or slightly
before the moment of shock delivery with a suppression occurring
immediately prior to shock. Subsequent to shock little behavior
is evident. Three separate intershock intervals have been chosen.
It can be noted that the lengthened intervals contribute to higher
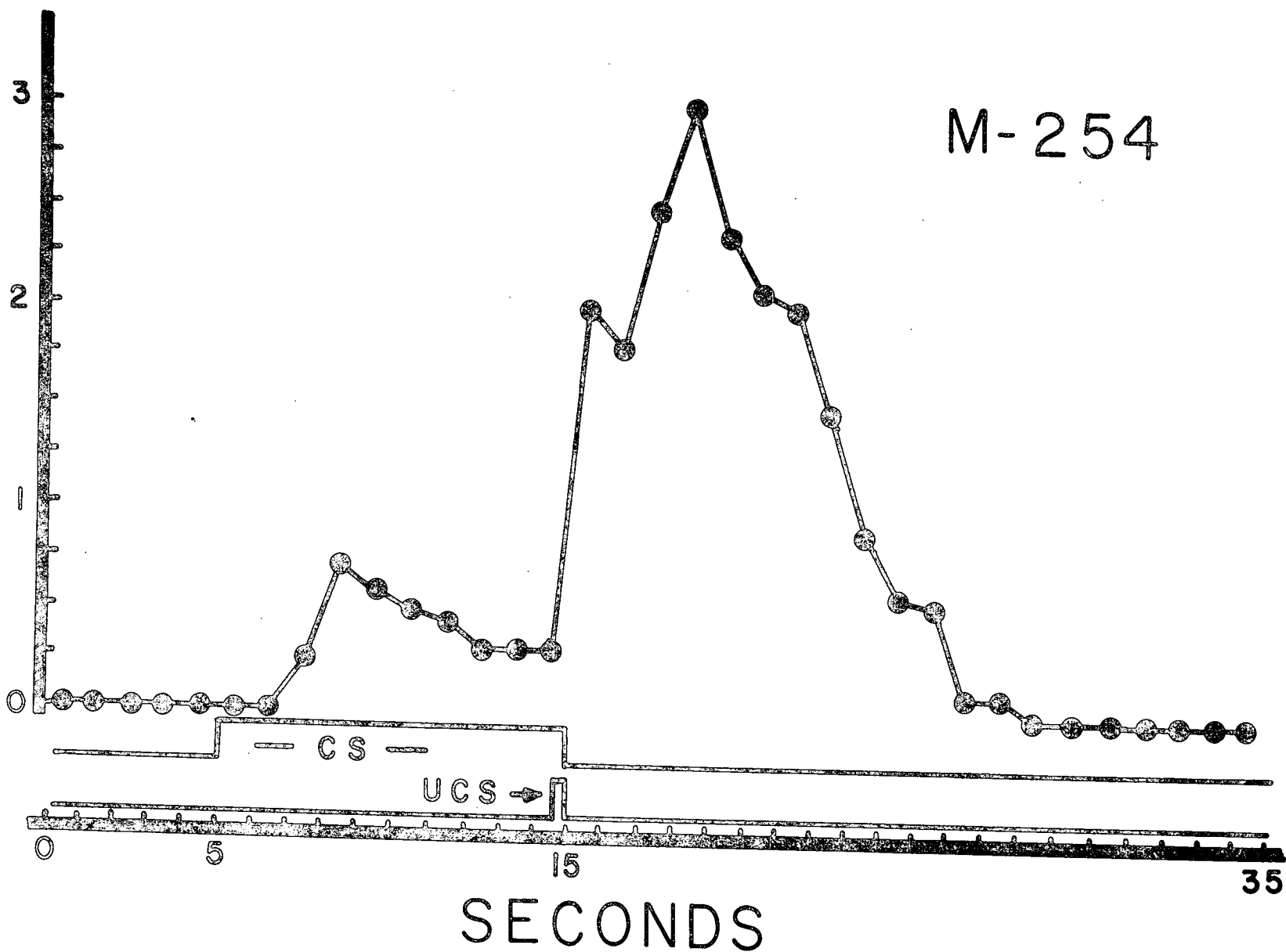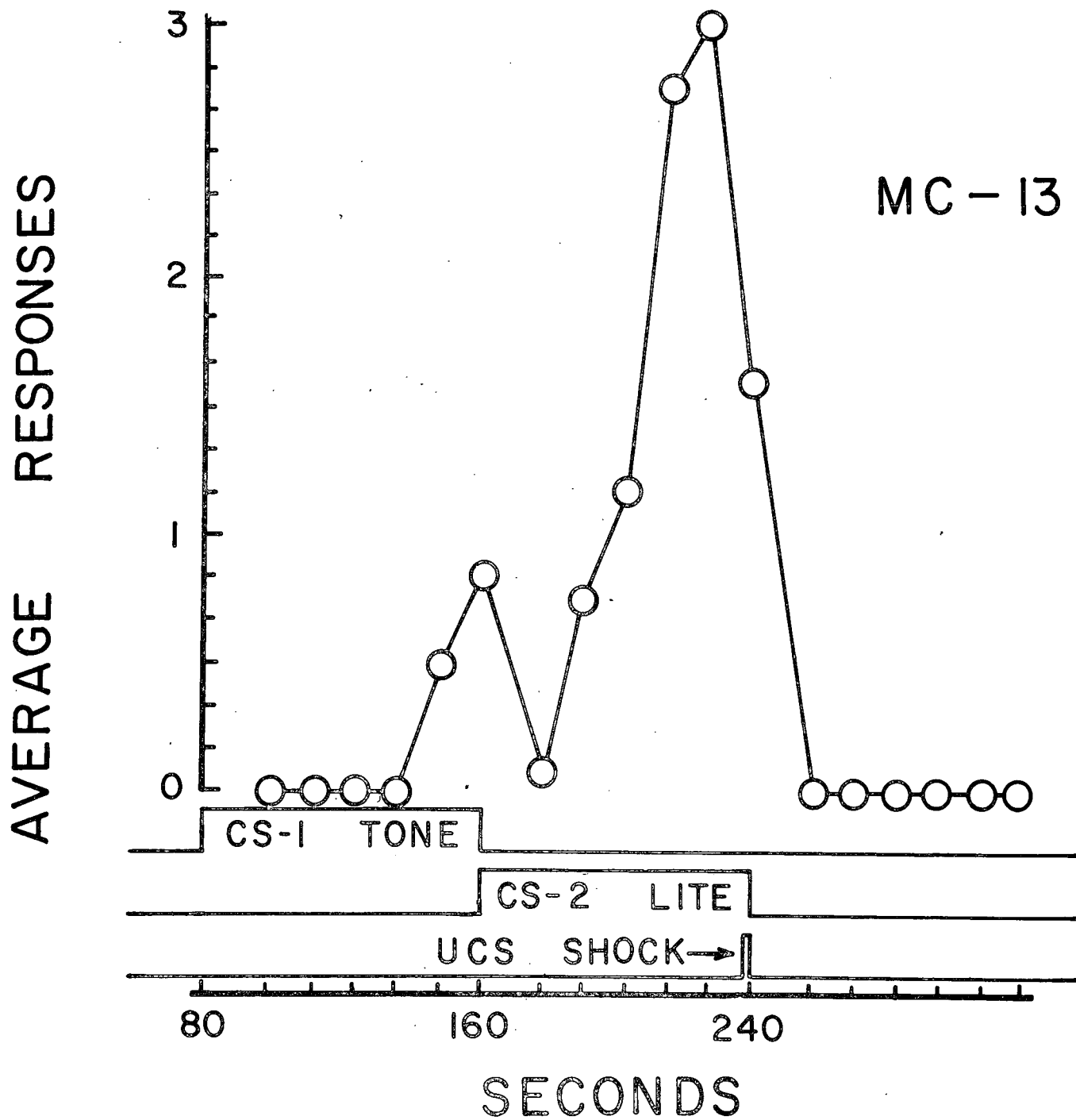overall response rates.

Figure 10. Average bite responding during intershock intervals by one subject in one 60-minute session. The CS was a flashing white light and the UCS was tail shock.

Figure 11. Average lever-press responding prior to shocks during intershock-intervals/stimuli by one subject during one 60-minute session.
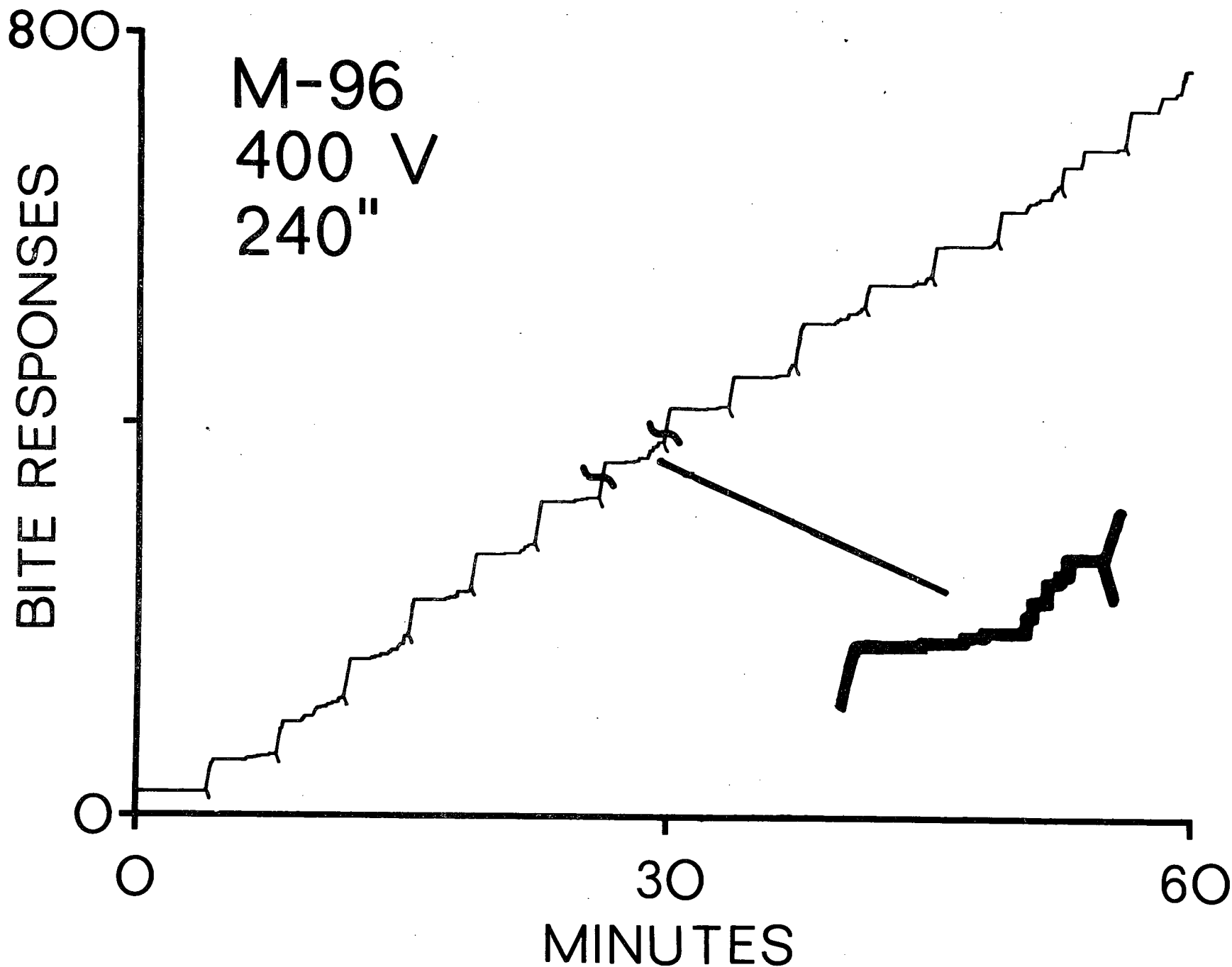
Figure 12. Cumulative record of biting attack by a single subject during one session of noncontingent shocks, indicated by vertical deflections of the record. A characteristic segment of inter-shock responding, showing a burst of biting as shock time approaches, is shown magnified in the lower right.

Figure 13. Cumulative records of lever-press responding by a
single subject exposed to one-hour daily sessions of non-
contingent shock for a prolonged period. The intershock interval
was 4 minutes on day 199, 8 minutes on day 224, and 12 minutes
on days 235 and 241.

C. Differential Influences of Stimuli Upon Different Response Classes

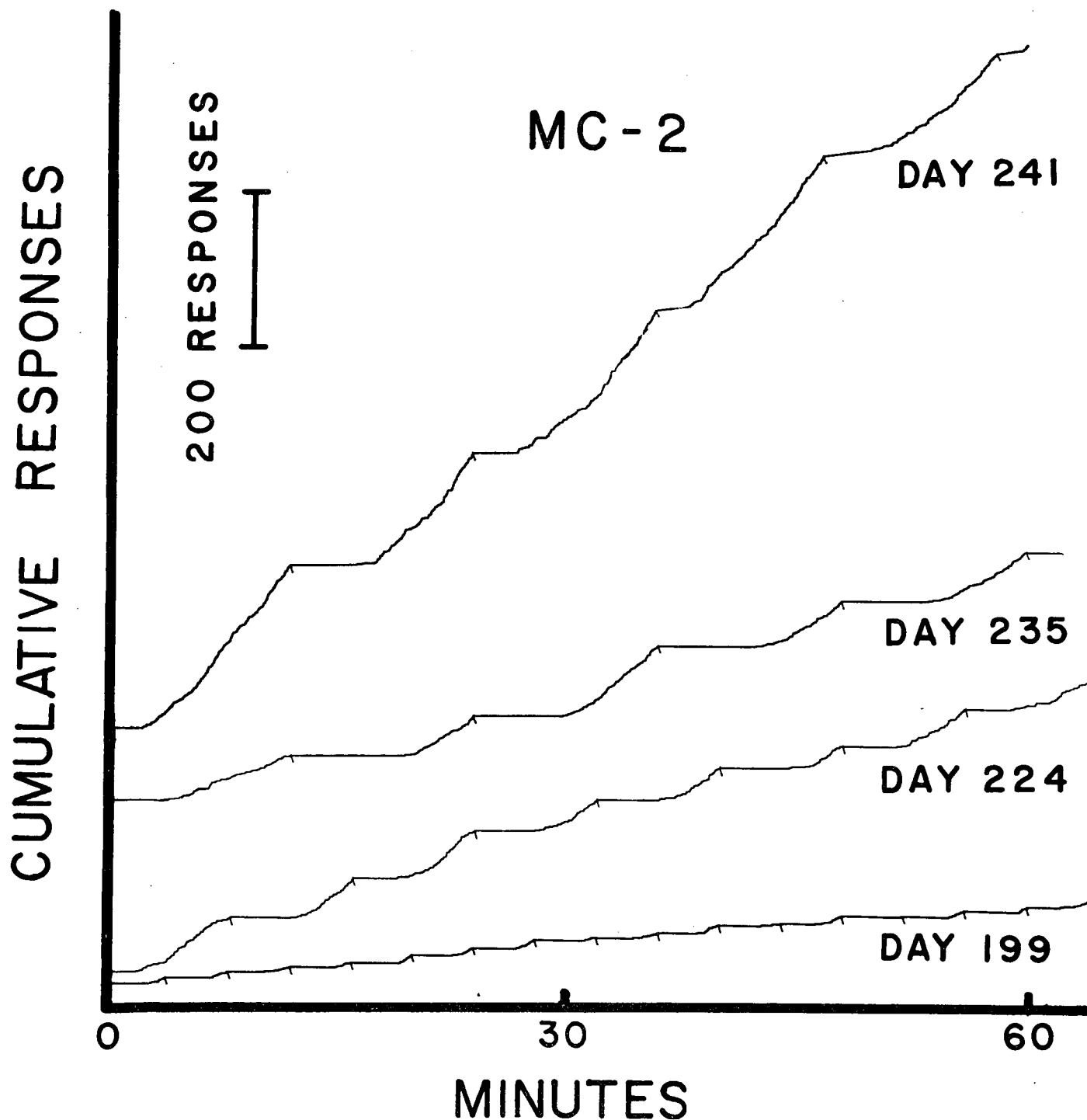So far, we have shown that the direct delivery of electric shock can produce biting attacks and/or manual manipulation responses, and that each of these phenomena may habituate to continuing exposure to high frequency, low intensity shocks or may show progressive facilitation if high intensity, infrequent shocks are delivered. Further, we have seen that both of these classes of behavior may eventually be produced by stimuli associated temporally with shock deliveries. Also, even in the absence of external stimuli, temporal conditioning develops. Additionally, these performances each illustrate an additional complexity in that they frequently reflect a suppression immediately before shock delivery. Though not discussed explicitly to this point, several comparisons between Figures 10 and 11, and between Figures 12 and 13, clearly point out separate and dissimilar temporal patterns of biting attack and manual manipulation. In fact, when both responses are <u>simultaneously available</u>, predictable but dissimilar concurrent performances develop. Figure 14 provides illustrations of concurrent biting attack and manual chain pulling or lever pressing by four subjects for an entire experimental session. The left panel of this figure illustrates the actual cumulative records. The overall pattern of performances is characterized by high-frequency biting immediately following shock, with a reduction in biting until later in the interval. Alternatively, response frequency for the manual manipulative responses is low immediately subsequent to shock and becomes progressively higher as the next shock approaches. Occasionally, even when both manual manipulation and biting attack responses are available, some subjects show a measurable degree of attack even prior to shock delivery. For example, subjects MC-28 and MC-13 each show some biting prior to shock. Immediately subsequent to shock, however, manual manipulative responding is absent and the relative frequency of behavior shifts toward biting attack. These performances are summarized in the right-hand portion of Figure 14. Again it may be noted that responding immediately prior to shock is reduced as compared with responding earlier. Thus the suppression phenomenon is evident here even in the concurrent response situation. The data in Figure 14 illustrate that the response classes of biting attack and manual manipulation are separable, not only on the basis of topographical considerations, but perhaps more importantly, on the basis of the differential influences of shock. Manual manipulative responding for all subjects does, at some point prior to shock, exceed the performance of biting attack in relative probability, whereas subsequent to shock delivery, the relative probability of biting attack exceeds that of manual manipulation for all subjects. This shift, in the relative probabilities of the two concurrent performances on the basis of an independent environmental event, serves to argue strongly that the effects are not due to idiosyncratic elements of chamber design or response sensor dimensions. In fact, the data suggest that the class of performance characterized

Figure 14. Concurrent biting attack and manual responses by four subjects during single, 60-minute sessions of noncontingent tail shock at 240-second intervals. Actual cumulative records are shown on the left, while entire-session averages of pre-and post-shock responding is summarized on the right.
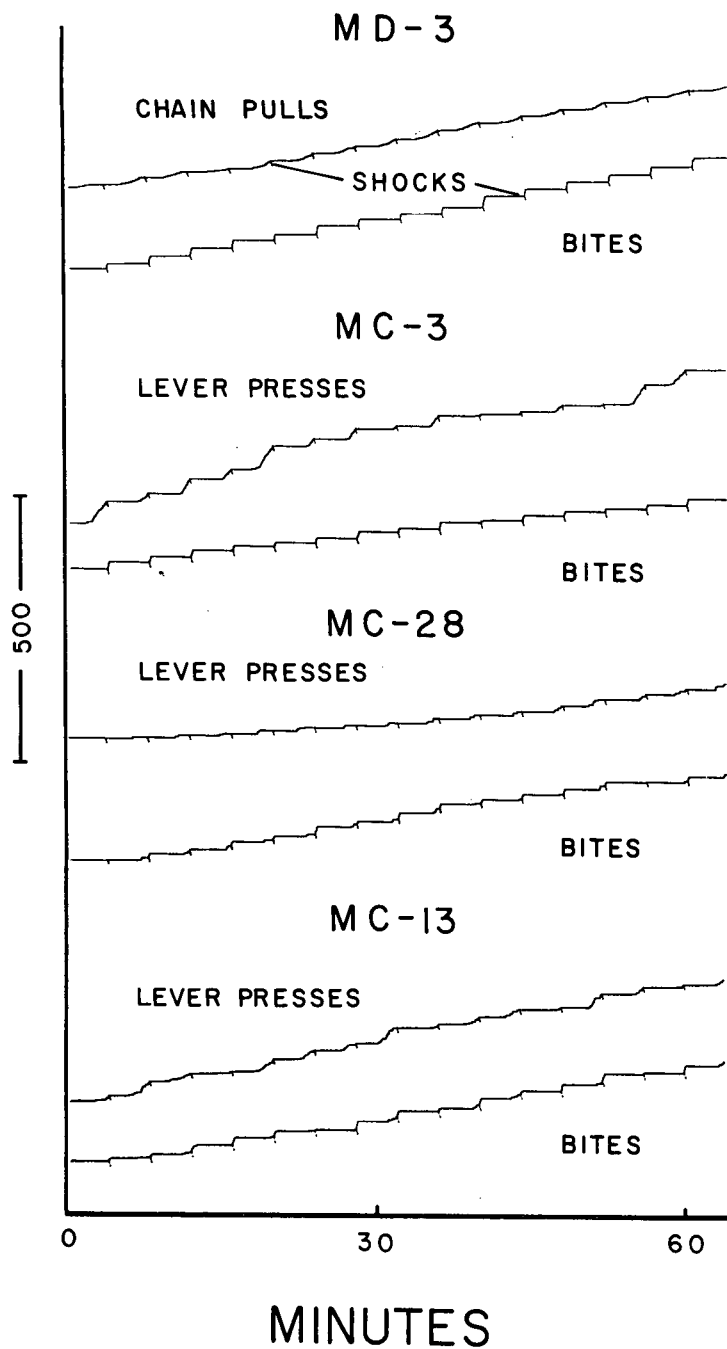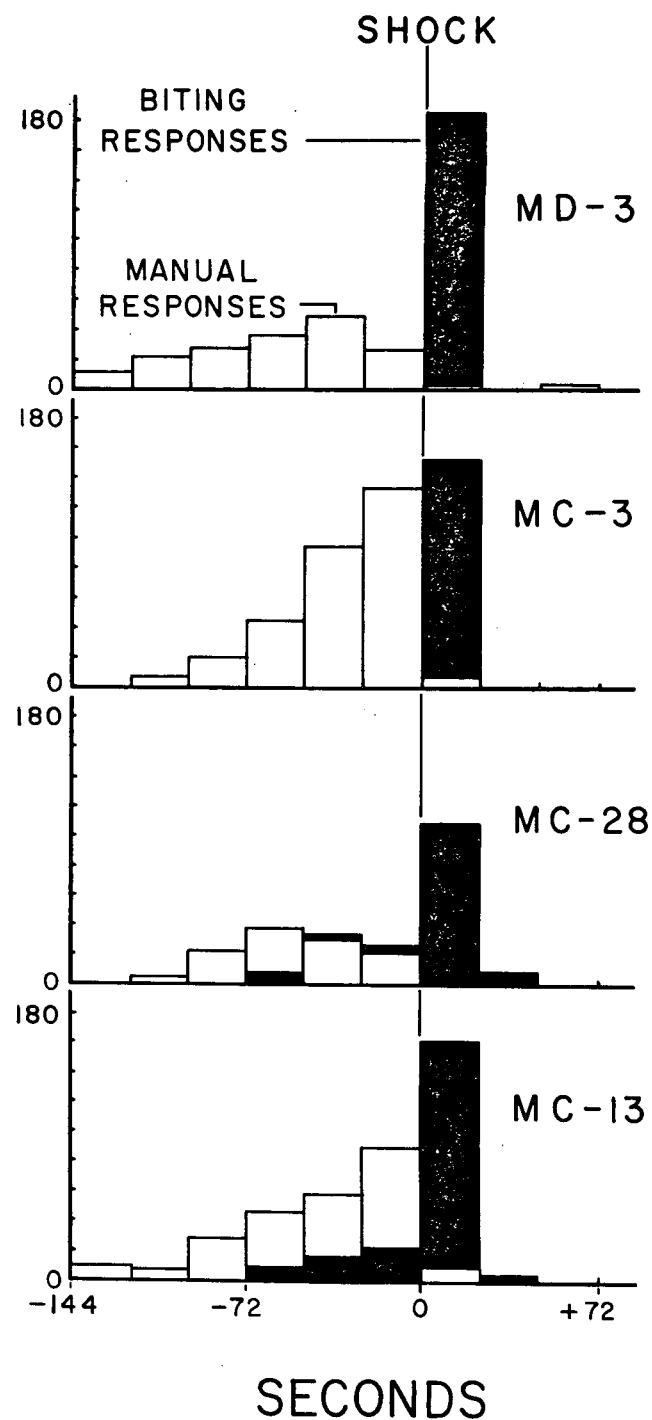
as movement through, and manual manipulation of, the environment is the class of response which strongly predominates prior to the occurrence of a noxious event. Alternatively, the data suggest that movement through, and biting attack upon, the environment predominates over other reaction tendencies subsequent to the occurrence of a noxious event. Additionally of course, both reaction patterns show a general suppression immediately before the noxious event.

What of the situation where both responses are not possible? More recently yet we have conducted several experiments designed to assess the influence upon manual manipulative responding of the presence and absence of the opportunity for biting attack. This data is thoroughly presented in Hutchinson and Emley (1971). In Figure 15, the performance of two representative animals is illustrated. The upper figures demonstrate the total daily responding of both manual manipulation and biting attack responses before and after shock over successive days of testing. During this series of tests the rubber hose was removed from the chamber for a period of days and the effect of such removal upon the lever-press and chain-pull responses for the two subjects was assessed. The conditions of before shock and after shock represent an arbitrary bisection of the intershock interval into a first and last half. This has been found suitable to differentiate the anticipatory responding ordinarily shown in the manual manipulative mode from the biting attack reactions seen after shock. The upper portions of Figure 15 illustrate that initial performance shows that the exclusive or large majority of manipulative responses occurs before shock, whereas biting attacks occurred almost exclusively after shock. Subsequent to the removal of the rubber hose, marked changes occurred in the manual response performances. Now, both subjects showed response flurries on the chain and lever subsequent to shock. It is seen that this post-shock manipulative responding is raised considerably in the absence of a hose. In one case, (MD-3) the post-shock manipulative responses approximately equalled the previous post-shock biting reactions when a hose had been available. An additional and more intriguing result is the marked elevation of before-shock manipulative responding during the hose-absent condition. In the lower portion of Figure 15, sample cumulative records are shown for typical days during each of the three conditions. In the centermost plots, two separate days of manipulative responding are illustrated. It may be seen that the frequency of preshock manual manipulations is considerably increased during hose absence. It should be pointed out that these responses in no way represent the additional accrual of biting attacks toward the response lever. Visual observations confirmed that such did not occur for several animals, and for several tests, a neck-yoke restraint device prevented the head from contacting the lever or chain.
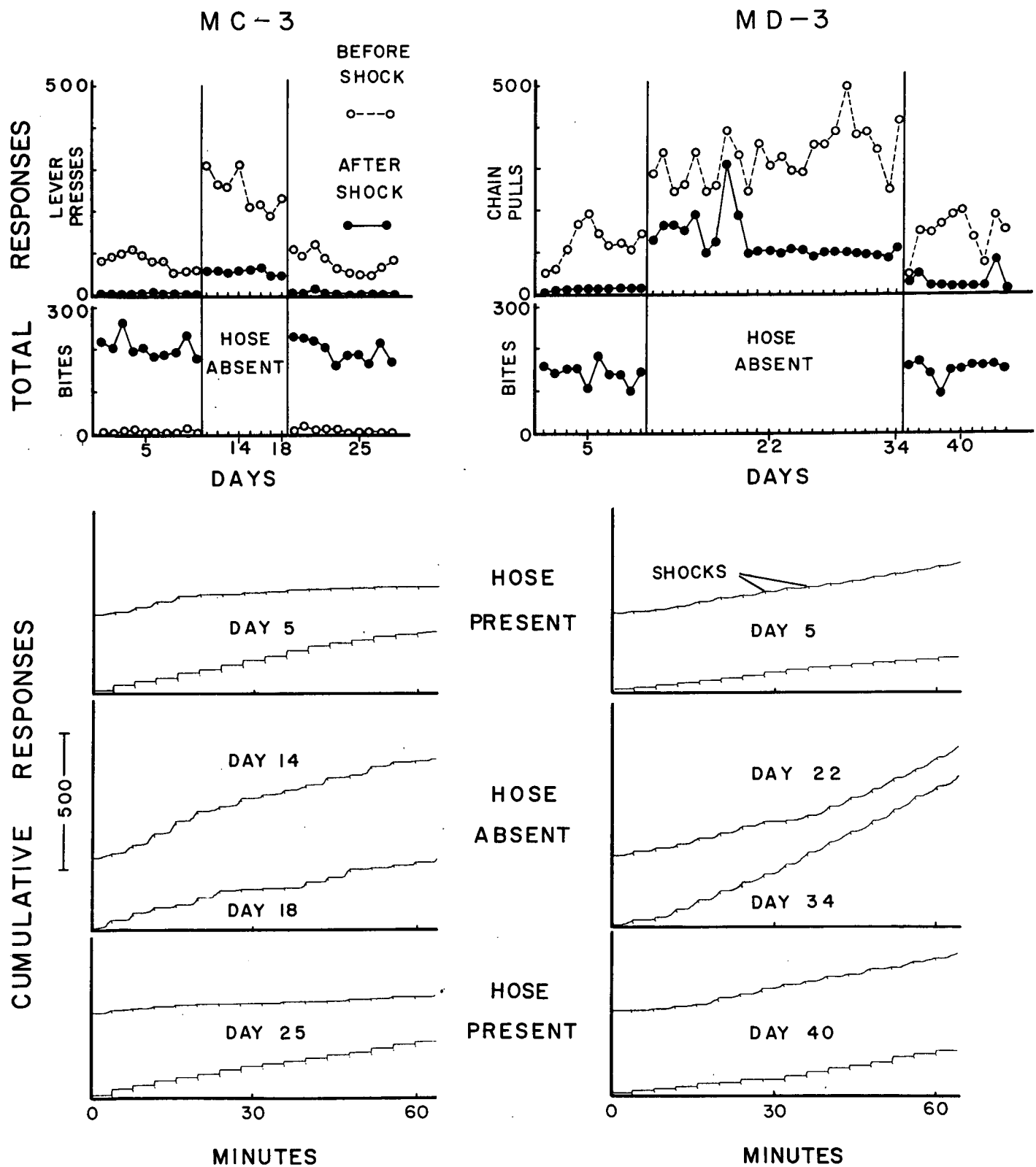
Figure 15. Manual responding by two subjects, each with and without access to a rubber bite hose. On days 5, 25 and 40, the upper cumulative record is of manual responding and the lower record is of biting. On days 14, 18, 22 and 34, the cumulative record is of manual responding. On all cumulative records, shock deliveries are indicated by vertical deflections.

The data of Figure 15 suggest that the absence of the opportunity to engage in biting attack reactions markedly elevates the tendency to engage in anticipatory manual manipulative reactions prior to shock and, additionally, fosters the production of post-shock manual response bursting. It is perhaps not totally irrelevant to point out that the increments in both pre-shock and post-shock manipulative responding by removal of the hose mimic rather closely the effects often observed upon manipulative responding subsequent to the increase in shock intensity. Strong presumptive evidence thus exists that biting actually serves to reduce certain of the effects of shock delivery.

IV. Some Differential Effects of Several Drugs Upon Different
     Response Classes

In the experiments described so far, two grossly different
topographical performances were each controlled by the same event,
the response-independent delivery of electric shock or stimuli
associated with shock. As this work has progressed and we have
come to understand a little more about preshock performances, it
appears more likely that the manual manipulative behaviors prior
to shock might in fact reflect upon certain basic motivational or
"emotional" processes normally interacting with contingency
programs during punishment or escape and avoidance conditioning.
Said another way, we came to suspect that these anticipatory
performances represented a reinforcement-free index of the strength
of unconditional and conditional noxiousness or aversiveness. In
recent experiments, discussed in detail in Emley and Hutchinson
(1970), several parmacological agents have been administered to
subjects during these shock-maintained behavior experiments. In
Figure 16, representative performances from four subjects, each
exposed to a separate pharmacological compound, are illustrated.
The dose response curves for the four compounds, as they have
influenced biting attack and lever press performances, are
separately illustrated. It may be seen that morphine produces
progressive decreases in both biting attack and lever pressing.
Alternatively, chlorpromazine progressively suppressed biting
attack performance but actually enhanced preshock lever pressing
throughout the range of its suppressive effect upon biting attacks.
Alternatively, the effect of chlordiazepoxide was generally to
enhance preshock lever pressing in the dosage ranges which had
relatively little effect upon biting attack. At a higher dosage,
however, both biting attacks and lever presses were suppressed.
With amphetamine, both biting attack and preshock lever pressing
are progressively elevated until biting attacks are abruptly
suppressed, even at dosages which maintain an exceptional degree
of preshock lever pressing. At higher dosages yet, lever pressing
is also depressed. The control ranges indicated in Figure 16 are
those for the preceding saline control days. Drug testing was
conducted each Wednesday of a five-day experimental week.

It has been exciting to have two concurrent performances
within the same subject differentially affected by the same drug
at the same dosage during the same experimental session. The
exceptional experimental power attendant upon such built-in control
procedures warrants consideration in further investigations by
others interested in the effects of chemical compounds on such
indices of aversive-stimulus motivated behaviors.

Figure 16. Relative biting attack and lever pressing by four subjects under the influence of the compounds and dosages indicated. The full-width dashed lines indicate the average saline-control behavioral levels for each subject and response, while ranges are shown by the vertical lines. Zero-level behavior is indicated by the short dashed lines at the right of each frame.
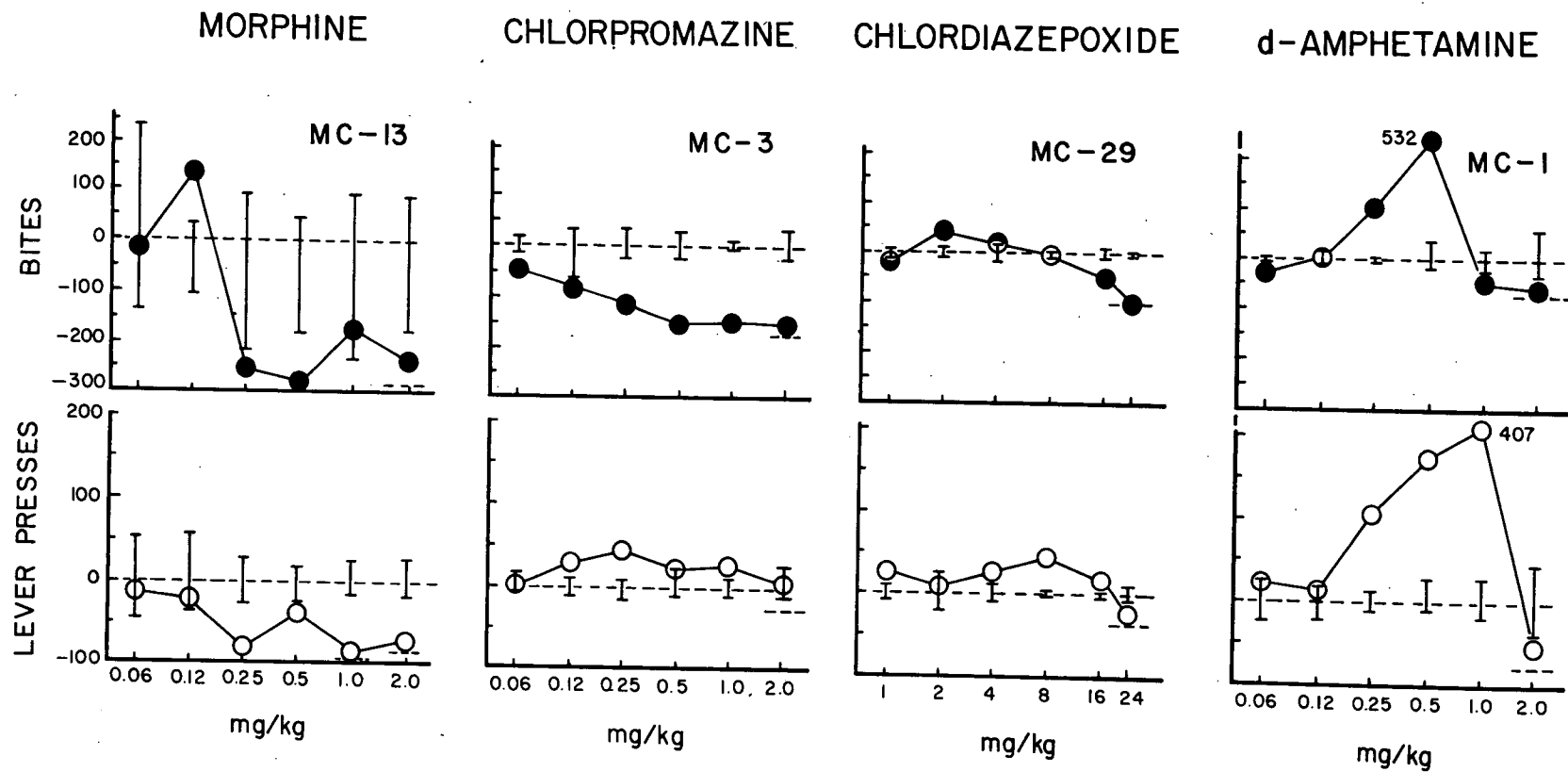
V.   Discussion

Prolonged exposure to intense, infrequent electric shock has been shown to produce two distinguishable response patterns. The behaviors of both attack and manual manipulation were shown to progressively increase, not only over successive instances of shock, but also over successive sessions. The temporal and intensive properties of this facilitation process suggests that the effect is, at least in part, humorally mediated. This seems possible since the accelerated responding typically occurs between 20 and 40 minutes after shock exposure commences. Other workers have reported similar response changes in the avoidance paradigm (Hoffman, Fleshler, and Chorny, 1961). In the present work, the effects are shown not to be limited to performances maintained momentarily by consequence control. Rather, the facilitation process appears general to at least several different response systems.

Progressive increases in both manual manipulation and biting attack, up toward the moment of shock occur in a temporal conditioning situation, or during explicit instatement of discrete shock-paired stimuli. With both of these conditioning effects, however, it was seen that stimuli most proximal associated with the shock event in fact produced response suppression or reduction. <u>Thus a progressive increase in some aspect of conditional stimulation results in a general progressively heightened tendency toward action until, at maximal levels, a major inversion to suppression occurs.</u>

An analysis of the temporal and intensive interactions between biting attack and manual manipulation demonstrated a characteristic pattern of interaction between these performances for all subjects. Generally, manual manipulative responses became progressively elevated toward the moment of shock. Additionally, there was some biting attack, though to a relatively lesser degree, which also increased toward the moment of shock. Each of these response classes often tended to be reduced or absent immediately before shock. Subsequent to shock, biting attacks predominated over other behaviors and progressively decreased over succeeding seconds.

In the past, we have attempted to provide the rationale for viewing biting attack behavior as a sensitive and valid index of more naturalistic attack reactions. The anticipatory manipulative responding seems likely to be our index of escape or flight tendency free of contingency influences through shock reduction or elimination. Though this is a speculative and largely unsupported assumption, its eventual support will allow data from the present discussion to form the basis for an important, experimentally based statement of the temporal and intensive relations between escape and attack performances.

The data may then be seen as a suitable model for the study of the temporal and intensive interactions between "fleeing", "freezing", and "fighting".

Evidence does exist to suggest that the anticipatory manual responding described is closely related to escape or avoidance behavior. The facilitation process already discussed closely parallels the "warm-up" effects during Sidman avoidance performance, reported and discussed by Hoffman, Fleshler and Chorny (1961). The temporal pattern of responding seen here bears a close similarity to that shown by Anger (1963), Sidman (1966), and Hoffman (1966) for avoidance performance. The tendency toward response suppression or reduction immediately before shock, though only infrequently observable in the situation where a response terminates or postpones shock occurrences, has nevertheless been reported and discussed previously (Hoffman, 1966). Thus, the patterns of performance during both initial and terminal conditions, as illustrated in the present paper, bear a striking and consistent similarity to performances which are in part dependent upon the contingent control of shock reduction or removal, i.e., escape and avoidance performance. Though in no way constituting proof, such regularities provide additional reason to pursue the possibility that the manual behaviors observed under free shock conditions are in fact an accurate index of escape or avoidance motivation.

The similarities reported here between response-independent, shock-produced behaviors and behavior ascribed to result from contingent shock control, place a constraint on estimates of the nature and/or degree of control actually exerted by the contingency per se in such situations (Morse and Kelleher, 1966; Kelleher and Morse, 1968; McKearney, 1968, 1969). In fact, free shock testing subsequent to avoidance has produced performances essentially identical with those reported here (Kelleher, Riddle, and Cook, 1963; Sidman, Herrnstein, and Conrad, 1957; Sidman, 1960; Byrd, 1969). A more detailed discussion of this position may be found in Hutchinson, Renfrew, and Young (in press).

To the extent that the performances studied here actually reflect upon or provide indices of general reaction tendencies occurring in the natural repertoire of organisms, the experimental paradigms may be helpful in other studies of both a theoretical and practical interest. For example, we have illustrated differential reliable differences between the effects of different, commonly employed psychotropic compounds upon these several shock-generated performance baselines. Hopefully, results of other studies similar to these will be available in the near future.

To this point we have illustrated how gradually we came to discover several features of and interactions between anticipatory manual responses and the more "reflexive" attack reactions to the intense shock stimulus. What would be the effect of other powerful recurrent stimuli, perhaps even of a positive reinforcing type? About a year ago we put this and related questions into experimental terms. Squirrel monkeys were partially restrained in a fashion almost identical to that described earlier in this paper except that tail electrodes were not applied. Subjects were food deprived and tested for one hour daily. Banana and regular flavored Noyes food pellets of various sizes from 45 to 300 mg. were then delivered on a response-independent fixed-time schedule. Within the chamber was a small rodent response lever, and/or an overhead chain mounted in a fashion similar to that used for the shock studies. We were quite amazed to discover that the recurrent delivery of food pellets gradually produced more and more manual responding. Figure 17 presents some of the data for three of six subjects thus tested. Each subject shows a progressive, though gradual increase in responding over subsequent test sessions. Each subject also shows a characteristic gradually developing pattern of responding within the inter-pellet interval. Shortly after pellet delivery a burst of responding occurs. Response rate is then low until later in the interval when it again increases until slightly before the time of the next pellet delivery when responding is again suppressed. Thus the pattern of manual responding here generated by the response-independent delivery of an agent known to possess primary positive reinforcement character-istics is similar, if not identical to behavior shown to have evolved in an essentially identical environment upon the delivery of response-independent electric shock. (Refer to Figure 15 during those days when no hose was available.)

These effects and how they may relate to patterns of performance generated by response contingent schedules of the same reinforcer type agents is presently being pursued. We can be certain at least at the present time that in schedules of positive reinforcement there are powerful eliciting and other response-generating effects which are not directly or indirectly the result of the contingency but rather, the direct effect of simply arranging contact between the organism and a powerful stimulus. What is the true topographic and functional breadth of reactions generated following food pellet delivery during deprivation, an electric shock or other strong "biologically relevant" stimuli? Similarly, what breadth of reaction topographies and what functional interrelationships result anticipatorily prior to such strong events such as food and shock? These are questions which we are only now beginning to answer. Our findings on these and related questions will almost certainly provide assistance toward a greater understanding of a variety of individual and social behaviors.
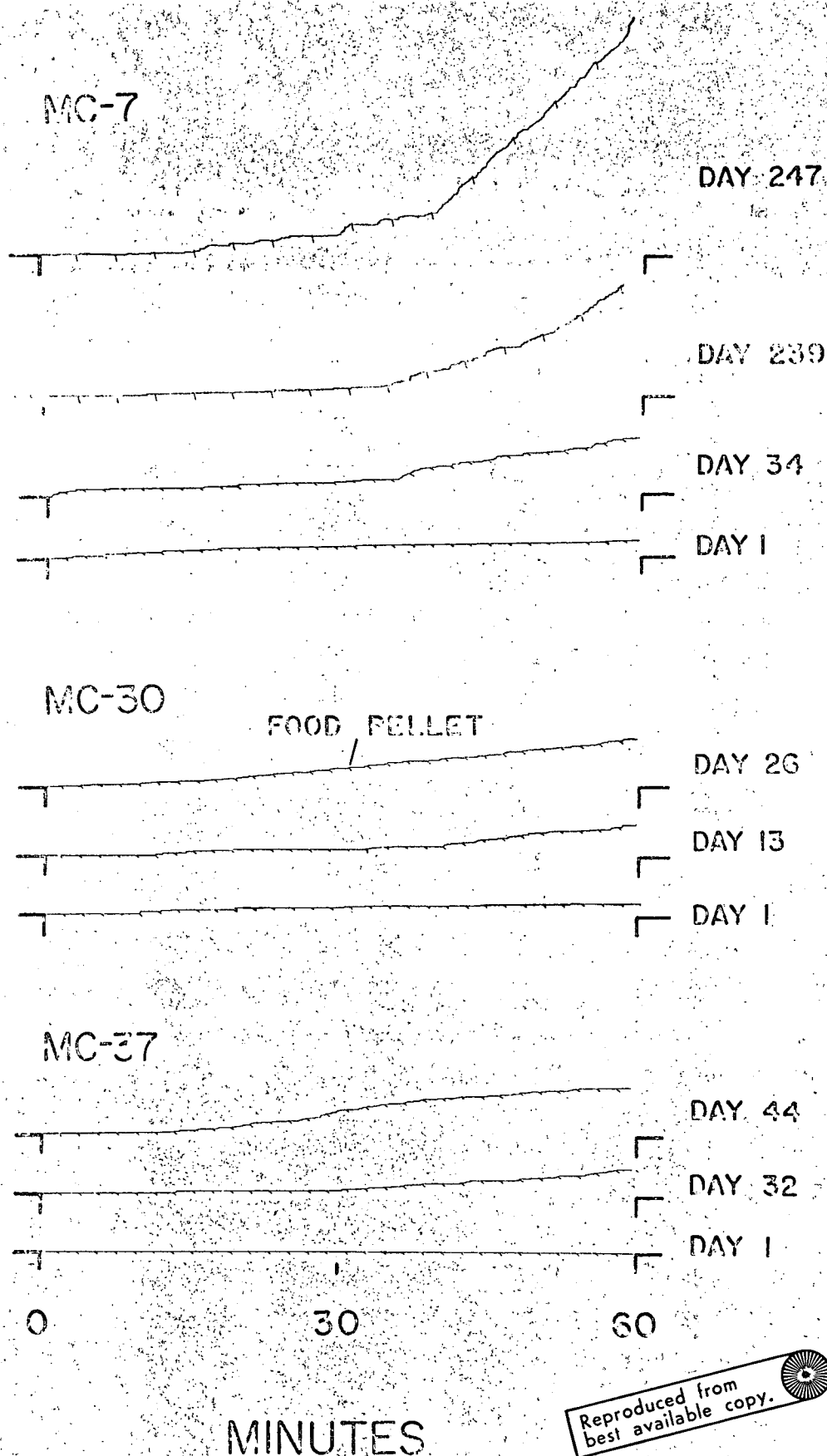
Figure 17. Sample cumulative records of performance of three squirrel monkey subjects over successive days of exposure to the response-independent delivery of food pellets. Each subject was food deprived and maintained at 70-80 percent of its free feeding weight. Pellet deliveries are indicated by the downward vertical deflections on the response pen tracing.

VI.   References

Anger, D., The role of temporal discriminations in the reinforce-
      ment of Sidman avoidance behavior. J. exp. Anal. Behav.,
      1963, 6, 477-506.

Appel, J. B., Aversive aspects of a schedule of positive reinforce-
      ment. J. exp. Anal. Behav., 1963, 6, 423-428.

Azrin, N. H., Time-out from positive reinforcement. Science,
      1961, 133, 382-383.

Azrin, N. H., Hutchinson, R. R., and Hake, D. F., Extinction-
      induced aggression. J. exp. Anal. Behav., 1966, 9, 191-204.

Azrin, N. H., Hutchinson, R. R., and Hake, D. F., Attack, avoidance,
      and escape reactions to aversive shock. J. exp. Anal. Behav.
      1967, 10, 131-148.

Byrd, L. D., Responding in the cat maintained under response-
      independent electric shock. J. exp. Anal. Behav., 1969,
      12, 1-10.

Emley, G. S., and Hutchinson, R. R., Modification of shock-
      induced biting attack by certain stimulant and depressant drugs.
      (in preparation)

Ferster, C. B., Control of behavior in chimpanzees and pigeons
      by time out from positive reinforcement. Psychol. Monogr.,
      1958, 72 (whole No. 461)

Hake, D. F., and Azrin, N. H., An apparatus for delivering pain shock
      to monkeys. J. exp. Anal. Behav., 1963, 6, 297-298.

Hoffman, H. S., The analysis of discriminated avoidance. In Honig,
      W. K. (ed.), Operant Behavior: Areas of Research and Application,
      New York: Appleton-Century, 1966, 499-530.

Hoffman, H. S., Fleshler, M., and Chorny, H., Discriminated bar-
      press avoidance. J. exp. Anal. Behav., 1961, 4, 309-316.

Hutchinson, R. R., Azrin, N. H., and Hake, D. F., An automatic method
      for the study of aggression in squirrel monkeys. J. exp. Anal.
      Behav., 1966, 9, 233-237.

Hutchinson, R. R., Azrin, N. H., and Hunt, G. M., Attack produced
      by intermittent reinforcement of a concurrent operant response.
      J. exp. Anal. Behav., 1968, 11, 489-495.

Hutchinson, R. R., Azrin, N. H., and Renfrew, J. W., Effects of shock intensity and duration on the frequency of biting attack by squirrel monkeys. J. exp. Anal. Behav., 1968, 11, 83-88.

Hutchinson, R. R., and Emley, G. S., Effects of opportunity to attack on pre-shock manipulative responses. (in preparation)

Hutchinson, R. R., Renfrew, J. W., and Young, G. A., Effects of long-term shock and associated stimuli on aggressive and manual responses. J. exp. Anal. Behav., in press.

Kelleher, R. T., and Morse, W. H., Schedules using noxious stimuli III. Responding maintained with response-produced electric shocks. J. exp. Anal. Behav., 1968, 11, 819-838.

Kelleher, R. T., Riddle, W. C., and Cook, L., Persistent behavior maintained by unavoidable shocks. J. exp. Anal. Behav. 1963, 6, 507-517.

McKearney, J. W., Maintenance of responding under a fixed-interval schedule of electric shock presentation. Science, 1968, 160, 1249-1251.

McKearney, J. W., Fixed-interval schedules of electric shock presentation: Extinction and recovery of performance under different shock intensities and fixed-interval durations. J. exp. Anal. Behav., 1969, 12, 301-313.

Morse, W. H., and Kelleher, R. T., Schedules using noxious stimuli. I. Multiple fixed-ratio and fixed-interval termination of schedule complexes. J. exp. Anal. Behav., 1966, 9, 267-290.

Sidman, M., Normal sources of pathological behavior. Science, 1960, 132, 61-68.

Sidman, M., Avoidance Behavior. In Honig, W. K. (ed.), Operant Behavior: Areas of Research and Application, New York: Appleton-Century, 1966, 448-498.

Sidman, M., Herrnstein, R. J., and Conrad, D. G., Maintenance of avoidance behavior by unavoidable shocks. J. Comp. Physiol. Psychol., Vol. 50, No. 6, Dec. 1957.

Thompson, D. M., Escape from Sd associated with fixed-ratio reinforcement. J. exp. Anal. Behav., 1964, 7, 1-8.

Thompson, D. M., Punishment by Sd associated with fixed-ratio reinforcement. J. exp. Anal. Behav., 1965, 8, 189-194.

Ulrich, R. E., and Azrin, N. H., Reflexive fighting in response to aversive stimulation. J. exp. Anal. Behav., 1962, 5, 511-520.